Structure and Function of Cells, Organs and Organ Systems

Cell Structure and Function

All living organisms are made up of one or more cells. A cell is the smallest unit that can carry out the activities of life. In these diagrams of an animal cell and a plant cell, it looks as though nothing is happening. However, real cells are full of activity.

The different parts of the cell work together to accomplish the multiple functions of the cell. For example, some cells in your body secrete proteins such as:

- protein hormones (e.g. insulin)
- protein enzymes that digest our food
- proteins that help our blood to clot.

1. A protein that will be secreted from the cell is:
   - made by a ________________ in the rough endoplasmic reticulum,
   - processed in the rough endoplasmic reticulum,
   - transported in a vesicle to the ________________,
   - processed some more in the Golgi apparatus, and
   - transported in a ________________ to the plasma membrane (cell membrane) where the protein is secreted.

2. Plant cells have several structures that are not found in animal cells. Choose two of the structures shown in this figure and explain why each of these structures is useful for plant cells, but not needed or even a disadvantage for animal cells.

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1 By Dr. Ingrid Waldron, Dept Biology, Univ. Pennsylvania, © 2019. This Student Handout, Teacher Notes with instructional suggestions, links to recommended videos, and biology background are available at http://serendipstudio.org/exchange/bioactivities/SFCellOrgan
3. If you think of a cell as a factory that makes proteins and ships them out, which parts of the cell accomplish each of the listed functions?

<table>
<thead>
<tr>
<th>Factory Function</th>
<th>What part of the cell accomplishes this function?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management — sends out instructions</td>
<td></td>
</tr>
<tr>
<td>(DNA → RNA)</td>
<td></td>
</tr>
<tr>
<td>Workbench — makes products (proteins)</td>
<td></td>
</tr>
<tr>
<td>Processing — prepares products to leave factory/cell</td>
<td></td>
</tr>
<tr>
<td>Structure and Transport — moves proteins around in factory/cell</td>
<td></td>
</tr>
<tr>
<td>Security Fence with Gates — controls what comes into and leaves the factory/cell</td>
<td></td>
</tr>
<tr>
<td>Powerhouse — provides energy in a form the factory/cell can use (ATP)</td>
<td></td>
</tr>
<tr>
<td>Cleanup crew — disposes of old and worn out products and equipment; prepares them for recycling</td>
<td></td>
</tr>
</tbody>
</table>

4a. Complete the following table.

<table>
<thead>
<tr>
<th>Activity of Life</th>
<th>Explain how one or more of the parts of an animal cell help the cell to carry out each of the listed activities of life.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeostasis (maintaining a stable internal environment)</td>
<td></td>
</tr>
<tr>
<td>Metabolism (using energy)</td>
<td></td>
</tr>
<tr>
<td>Growth (e.g. making proteins)</td>
<td></td>
</tr>
</tbody>
</table>

4b. Explain why biologists say that a cell is alive, but none of the individual molecules inside the cell are alive.
Many cells in our bodies do not look like the "typical" animal cell shown on page 1. Differences in cell shape and contents are related to differences in the function of different types of cells.

5a. This figure shows the specialized structure of sperm cells. Explain how the flagellum of a sperm cell contributes to its function.

5b. Why is it an advantage for sperm cells to have very little cytoplasm, but lots of mitochondria?

6. A capillary is a tiny blood vessel where:
   - Oxygen and nutrients diffuse from the blood to the cells near the capillary.
   - Carbon dioxide and other waste molecules produced by the cells near the capillary diffuse into the blood.

   Explain why it is useful for the walls of capillaries to consist of a single layer of thin, flattened cells.

A human red blood cell is specialized to carry lots of oxygen to the body’s cells. It is filled with hemoglobin, the protein that carries oxygen. It has no nucleus, ribosomes or mitochondria. As a result, human red blood cells have a reduced capacity for repair; each red blood cell only survives about four months, and then it has to be replaced.

7a. Describe the specialized characteristics of human red blood cells and explain how these characteristics help red blood cells to accomplish their function.

7b. Most cells are constantly replacing damaged molecules and organelles. Explain why a red blood cell is unable to replace damaged proteins.
Phagocytes are a type of white blood cell. When bacteria infect a wound, phagocytes leave the blood and defend your body against infection by engulfing, killing and digesting bacteria.

8. Why do phagocytes need to be able to change shape in order to accomplish their function?

9. In a typical diagram of a cell, it looks as though nothing much is happening. In reality, cells are highly dynamic, with lots of activity. Briefly describe five examples to illustrate the kinds of activity observed in cells.

a.

b.

c.

d.

e.

Structure and Function of Organs and Organ Systems

The cells in your body are organized into tissues, organs and organ systems.

• A tissue is a group of similar cells that serve a common function. You have already seen one example of a tissue – the cells that make up the capillary wall.

• An organ is a body part consisting of two or more tissues that cooperate to carry out a specific function in the body. Familiar body organs include your heart and your stomach.

• Multiple organs that have related functions combine to form an organ system that carries out a major body function. For example, the organs of the excretory system cooperate to get rid of metabolic wastes.
The organs in the **digestive system** cooperate to break down food into small molecules that are absorbed into the blood. These organs include the:

- **oral cavity** where teeth, jaw muscles and saliva work together to begin breaking down food into smaller particles
- **esophagus** which carries this mixture of food and digestive juices to the **stomach** where acid helps to kill any germs in the food; the stomach stores a meal and gradually releases small amounts of food for digestion in the small intestine
- **pancreas** and **liver** which supply the small intestine with enzymes and other molecules that aid in the digestion of food molecules
- **small intestine** where enzymes break down food molecules into smaller molecules that are absorbed into the blood; most digestion and absorption occur in the small intestine which is much longer than shown here
- **large intestine** where water is absorbed and the feces are stored for excretion.

The diagram above clearly illustrates the sequence of organs in the digestive system, but it does not give a realistic picture of the relative sizes and arrangement of these organs. These features of the digestive system are shown in the diagram below.

10. Match each organ with its function or functions.

   Organ A. ___
   Organ B. ___
   Organ C. ___  ___
   Organ D. ___

   a.  acid helps to kill any germs in the food
   b.  begins the breakdown of food into smaller particles
   c.  carries mixture of food and digestive juices from oral cavity to stomach
   d.  organ where most of the digestion by enzymes occurs and digested food molecules are absorbed into the blood
   e.  stores a meal and gradually releases small amounts of food for digestion in the small intestine
"Structure is related to function" is a general principle that applies to cells, tissues, organs, and organ systems. For example, in our digestive system, effective digestion depends on having each organ in the correct order from beginning to end.

11. Imagine a digestive system where food entered the small intestine directly without first going through the oral cavity and stomach. What would be the disadvantages of this type of digestive system? Why is it useful to have food processed in the oral cavity and stomach before entering the small intestine?

The small intestine is a very long and narrow tube (6-7 m long and 2.5 cm wide). The lumen (the space inside the small intestine) contains a mixture of digestive enzymes and food molecules that are broken down to small molecules that can be absorbed into the blood.

The structure of the wall of the small intestine contributes to the functions of digestion and absorption.

- The muscles in the wall of the small intestine contract repeatedly to mix the digestive enzymes with the food molecules.
- The many villi on the inner surface of the small intestine result in a very large surface area which increases the rate of absorption of digested food molecules from the lumen of the small intestine to the blood which carries nutrients to all the cells of the body.

12a. How does the muscle tissue in the wall of the small intestine contribute to the function of the small intestine?

12b. How do the many villi on the inner surface of the wall of the small intestine contribute to the function of the small intestine?

12c. How do the capillaries inside the villi contribute to the function of the small intestine?
13. The circulatory system includes the:
   - blood
   - blood vessels (including the capillaries)
   - heart, which pumps blood through the blood vessels to all the parts of your body.

Explain how the digestive system and circulatory system work together to bring nutrients to all the cells in your body.

Challenge Questions

14. A paramecium is a single cell organism with several differences in structure from the animal and plant cells shown on page 1. Use a reliable source such as a textbook to learn about the functions of the structures shown in this diagram. Explain how these structures support the paramecium’s activities of life (e.g. homeostasis, metabolism, and responding to the environment).

15. The grass that cows eat is much harder to digest than the foods that humans eat because the cell walls of grass have lots of cellulose and mammals do not produce enzymes that can break down cellulose. Cows need the help of bacteria and other microorganisms that make enzymes that break down cellulose into smaller molecules that can be absorbed into the blood and used by a cow's cells. Use a reliable source such as a textbook to learn about the differences in the structure of the digestive system of cows vs. people. What special features of a cow's digestive system contribute to efficient digestion of grass?